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Ruth Montalvo
Ruth Montalvo

25 April 02
Date

Docket No.: GK-ZEI-3125/500343.20126

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Ralf WOLLESCHENSKY and Michael KEMPE
Serial No.: 10/043,009
Filed: January 18, 2002
For: METHOD AND ARRANGEMENT FOR THE DEEP RESOLVED
OPTICAL RECORDING OR A SAMPLE

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to receipt of a first Office Action, please amend the above-identified application as follows:

IN THE SPECIFICATION

Cancel the present specification and substitute therefor the enclosed substitute specification.

IN THE CLAIMS

Page 33, line 1, change "Patent Claims" to –What is claimed is--.

Cancel claims 1-134 and add new claims 135-268, reading as follows:

--135. (New) A method for depth-resolved optical detection of a specimen comprising the steps of:

providing a scanning movement over the specimen or at least a part of the specimen of an illumination light distribution of at least one wavelength which is generated on or in the specimen;

providing detection particularly of the light which is influenced based on interaction with the specimen, especially fluorescent light; and/or reflected light and/or luminescent light and/or scattered and/or transmitted light;

said illumination light having a modulation in at least one spatial direction;
and

carrying out the scanning movement and detection associated with the scanning movement at least in a first and a second different phase position of the modulation and/or first and second frequency of the periodicity of the modulation; and

calculating at least one optical section image through the specimen or through part of the specimen.

136. (New) The method according to claim 135, wherein the modulation is carried out by impressing at least one structure which is spatially periodic in at least one dimension.

137. (New) The method according to claim 135, wherein the light distribution is imaged on the specimen.

138. (New) The method according to claim 135, wherein the section image is graphically displayed.

149. (New) The method according to claim 135, wherein with n wavelengths at least $n+1$ phase positions of the structure are detected.

150. (New) The method according to claim 135, wherein phase and/or frequency are adjusted differently for every wavelength for generating coding values.

151. (New) The method according to claim 135, wherein a wavelength-dependent phase coding and/or frequency coding of the illumination light is carried out and the optical section image is calculated per wavelength by means of the coding.

152. (New) The method according to claim 135, wherein the scan process is carried out with a line with a plurality of wavelengths.

153. (New) The method according to claim 135, wherein the scan process is carried out with a plurality of lines simultaneously.

154. (New) The method according to claim 153, wherein illumination is carried out with one or more wavelengths.

155. (New) The method according to claim 135, wherein, in the calculation of phase images ($I_j(x)$ with image phase: ϕ_i) with phase coding of the excitation wavelength (ϕ_j), images are calculated which contain the image information of the pseudo-confocal section (C_j) and of background (B_j), which image information is characteristic of the respective j th wavelength:

$$I_0(x) = \sum_{j=1}^n C_j(x) \cdot \cos(k \cdot x + \phi_j + \phi_0) + B_j(x)$$

$$I_1(x) = \sum_{j=1}^n C_j(x) \cdot \cos(k \cdot x + \phi_j + \phi_1) + B_j(x)$$

$$I_2(x) = \sum_{j=1}^n C_j(x) \cdot \cos(k \cdot x + \phi_j + \phi_2) + B_j(x)$$

...

$$I_n(x) = \sum_{j=1}^n C_j(x) \cdot \cos(k \cdot x + \phi_j + \varphi_n) + B_j(x),$$

wherein

$$\begin{pmatrix} c_{11} & c_{12} & \dots & \dots \\ c_{21} & c_{22} & \dots & \dots \\ \dots & \dots & \dots & \dots \\ c_{n1} & c_{n2} & \dots & c_{nm} \end{pmatrix} \cdot \begin{pmatrix} C_1 \\ C_2 \\ \dots \\ C_n \end{pmatrix} = \begin{pmatrix} I_1 - I_0 \\ I_2 - I_0 \\ \dots \\ I_n - I_0 \end{pmatrix},$$

where $c_{ij}(x) = \cos(k \cdot x + \phi_j + \varphi_i) - \cos(k \cdot x + \phi_j)$.

156. (New) The method according to claim 135, using a periodic structure whose period changes at least in one spatial direction (Y) vertical to the direction of periodicity (X).

157. (New) The method according to claim 135, using an optical arrangement with a dispersive unit which splits the illumination light into spectral components and joins it again and which has imaging optics for imaging the spectral components in a focal plane, wherein a periodic structure for influencing the illumination light in a wavelength-dependent manner is provided in or in the vicinity of the focal plane.

158. (New) The method according to claim 135, wherein the generation of optical section images is carried out by structured illumination by means of recording individual images with different modulation frequency and/or image phase.

159. (New) The method according to claim 135, wherein the optical section thickness is varied by changing the modulation frequency.

160. (New) The method according to claim 135, wherein a phase coding is carried out with simultaneous imaging of different wavelengths and/or line foci on a common detector.

161. (New) The method according to claim 135, wherein a frequency coding is carried out with simultaneous imaging of different wavelengths and/or line foci on a common detector.

162. (New) The method according to claim 135, wherein a plurality of wavelengths are imaged simultaneously with respect to time on the specimen.

163. (New) The method according to claim 162, wherein the imaging is carried out in a spatially separated manner or on a common location of the specimen.

164. (New) The method according to claim 135, wherein a wavelength is imaged on the specimen.

165. (New) The method according to claim 164, wherein the imaging is carried out in a repeatedly spatially separated manner or on a location of the specimen.

166. (New) The method according to claim 135, wherein the light distribution is imaged on the specimen in a line-shaped or point-shaped manner.

167. (New) The method according to claim 135, wherein a sequential recording of the individual images is carried out.

168. (New) The method according to claim 135, wherein a plurality of line-shaped and/or point-shaped light distributions are generated.

169. (New) The method according to claim 135, wherein a parallel recording of individual images is carried out.

170. (New) The method according to claim 135, wherein, with a plurality of wavelengths, the section thicknesses are preferably identically adjusted by changing the modulation frequency.

171. (New) The method according to claim 135, wherein the detection is carried out with point detectors and/or line detectors and/or matrix detectors.

172. (New) The method according to claim 135, wherein a wavelength-dependent phase coding is carried out by an arrangement for generating a wavelength-dependent parallel offset along the periodic structure.

173. (New) The method according to claim 135, wherein a wavelength-dependent phase coding is carried out by a tilted plate in an intermediate image.

174. (New) The method according to claim 135, wherein a wavelength-dependent phase coding is carried out by a dispersive element.

175. (New) The method according to claim 135, wherein a wavelength-dependent phase coding is carried out by an optical arrangement with a dispersive unit which splits the illumination light into spectral components and unites them again, which optical arrangement has imaging optics for imaging the spectral components in a focal plane, wherein a periodic structure is provided in or in the vicinity of the focal plane for wavelength-dependent influencing of the illumination light, wherein the structure is rotatable about the optical axis.

176. (New) The method according to claim 175, wherein the spectral splitting is carried out in an intermediate image.

177. (New) The method according to claim 135, wherein a frequency coding of a plurality of wavelengths is carried out by an optical arrangement with a dispersive unit which splits the illumination light into spectral components and unites them again, which optical arrangement has imaging optics for imaging the spectral components in a focal plane, wherein a periodic structure is provided in or in the vicinity of the focal plane for wavelength-dependent influencing of the illumination light, with a periodic structure whose period changes at least in one spatial direction (Y) vertical to the direction of periodicity (X).

178. (New) The method according to claim 135, wherein a frequency coding of a plurality of wavelengths is carried out in that the imaging scale is changed in a wavelength-dependent manner.

179. (New) The method according to claim 135, wherein a frequency coding of a plurality of wavelengths is carried out by an optical arrangement with a dispersive unit which splits the illumination light into spectral components and unites them again, which optical arrangement has imaging optics for imaging the spectral components in a focal plane, wherein a periodic structure is provided in or in the vicinity of the focal plane for wavelength-dependent influencing of the illumination light, with a structure composed of a plurality of parts of different periodicity.

180. (New) The method according to claim 135, wherein a sequential recording of the individual images is carried out with a change in the image phase.

181. (New) The method according to claim 180, wherein a displacement of the periodic structure is carried out at right angles to the optical axis.

182. (New) The method according to claim 135, wherein a sequential recording of the individual images is carried out with a change in the image phase by adjusting the position of the scanner.

183. (New) The method according to claim 135, wherein a sequential recording of the individual images is carried out with a change in the image phase by tilting a plane-parallel plate.

184. (New) The method according to claim 135, wherein a sequential recording of the individual images is carried out with a change in the modulation frequency.

185. (New) The method according to claim 135, wherein a sequential recording of the individual images is carried out with a change in the modulation frequency by a wavelength-dependent change in the imaging scale.

186. (New) The method according to claim 135, wherein a sequential recording of the individual images is carried out with a change in the modulation frequency by swiveling in different structures with different periodicity.

187. (New) The method according to claim 135, wherein a sequential recording of the individual images is carried out with a change in the modulation frequency by a displacement of a periodic structure, whose period changes at least in one spatial direction (Y) essentially vertical to the direction of periodicity (X), vertical to the periodicity.

188. (New) The method according to claim 135, wherein a plurality of light distributions are generated on the specimen and a parallel recording of the individual images is carried out.

189. (New) The method according to claim 188, with generation of a plurality of light distributions on the specimen with a wavelength, especially by splitting the illumination into a plurality of partial beams with a beam splitter arrangement comprising at least one full mirror and a partially transmitting mirror or splitting the illumination into a plurality of partial beams with at least one mirror and a reflecting periodic structure acting as beam splitter.

190. (New) The method according to claim 188, with generation of a plurality of light distributions on the specimen with a plurality of wavelengths, especially by splitting the illumination into a plurality of partial beams with a dispersive element or splitting the illumination into a plurality of partial beams by a beam splitter arrangement comprising at least one full mirror and a partially transmitting mirror or splitting the illumination into a plurality of partial beams with at least one mirror and a reflecting periodic structure acting as beam splitter.

191. (New) The method according to claim 135, wherein a parallel recording of the individual images is carried out with different phase positions of the illumination.

192. (New) The method according to claim 191, with a plurality of wavelengths, especially by means of an arrangement with a dispersive element and a periodic structure which is rotatable about the optical axis, wherein the dispersive element is preferably arranged in the intermediate image, and/or an arrangement with a dispersive

partially transmitting mirror or by splitting the illumination into a plurality of partial beams with at least one mirror and a reflecting periodic structure, wherein the periodic structure comprises parts of different periodicity.

197. (New) An arrangement for depth-resolved optical detection of a specimen, especially of the light of an illumination light distribution which is influenced based on interaction with the specimen, especially fluorescent light and/or reflected light and/or luminescent light and/or scattered and/or transmitted light, comprising:

- means for illuminating the specimen with at least one wavelength;
- means for generating a relative movement between the specimen and illumination light;
- means for imaging the light influenced by the specimen on at least one detector;
- means for imaging a structure which changes in a spatially periodic manner in at least one dimension in different phases and/or frequencies of the periodicity on the specimen; and
- means for calculating at least one optical section image from the local information of the light influenced by the specimen.

198. (New) The arrangement according to claim 197, wherein means are provided for graphically displaying the section image.

199. (New) The arrangement according to claim 197, wherein means are provided for imaging at least one interference pattern.

200. (New) The arrangement according to claim 197, wherein the illumination is carried out by means of a line-shaped light distribution which has an extension of up to diffraction limitation in the narrow direction and, in the other direction at right angles thereto, a multiple of this extension.

201. (New) The arrangement according to claim 197, wherein scanning is carried out in pointwise manner by means of the scanning movement.

202. (New) The arrangement according to claim 197, wherein a scanning movement of a line pattern and/or at least a one-dimensional or two-dimensional point pattern is carried out within a scan field.

203. (New) The arrangement according to claim 197, wherein a composite image is generated from the scanned line patterns and/or point patterns.

204. (New) The arrangement according to claim 197, wherein an equidistant raster of line patterns and/or point patterns is used.

205. (New) The arrangement according to claim 197, wherein the illumination light contains a plurality of wavelengths.

206. (New) The arrangement according to claim 197, wherein the scan process is carried out with a line with a plurality of wavelengths.

207. (New) The arrangement according to claim 197, wherein the scan process is carried out with a plurality of lines simultaneously.

208. (New) The arrangement according to claim 197, wherein scanning is carried out with one or more wavelengths.

209. (New) The arrangement according to claim 197, with a periodic structure whose period changes at least in one spatial direction (Y) vertical to the direction of periodicity (X).

210. (New) The arrangement according to claim 197, with an optical arrangement with a dispersive unit which splits the illumination light into spectral components and unites them again and which has imaging optics for imaging the spectral components in a focal plane, wherein a periodic structure for influencing the illumination light in a wavelength-dependent manner is provided in or in the vicinity of the focal plane.

211. (New) The arrangement according to claim 210, wherein the dispersive splitting is carried out in an intermediate image plane.

212. (New) The arrangement according to claim 197, wherein a phase coding is carried out with simultaneous imaging of different wavelengths and/or line foci on a common detector.

213. (New) The arrangement according to claim 197, wherein a frequency coding is carried out with simultaneous imaging of different wavelengths and/or line foci on a common detector.

214. (New) The arrangement according to claim 197, wherein a plurality of wavelengths are imaged simultaneously with respect to time on the specimen.

215. (New) The arrangement according to claim 197, wherein the imaging is carried out in a spatially separated manner or on a common location of the specimen.

216. (New) The arrangement according to claim 197, wherein a wavelength is imaged on the specimen.

217. (New) The arrangement according to claim 197, wherein the imaging is carried out in a repeatedly spatially separated manner or on a common location of the specimen.

218. (New) The arrangement according to claim 197, wherein the light distribution is imaged on the specimen in a line-shaped or point-shaped manner.

219. (New) The arrangement according to claim 197, wherein a sequential recording of the individual images is carried out.

220. (New) The arrangement according to claim 197, wherein a plurality of line-shaped and/or point-shaped light distributions are provided.

the illumination light into spectral components and unites them again, which optical arrangement has imaging optics for imaging the spectral components in a focal plane, wherein a periodic structure is provided in or in the vicinity of the focal plane for wavelength-dependent influencing of the illumination light, with a periodic structure whose period changes at least in one spatial direction (Y) vertical to the direction of periodicity (X).

230. (New) The arrangement according to claim 227, for frequency coding of a plurality of wavelengths, wherein the imaging scale is changed in a wavelength-dependent manner.

231. (New) The arrangement according to claim 227, for frequency coding of a plurality of wavelengths with an optical arrangement with a dispersive unit which splits the illumination light into spectral components and unites them again, which optical arrangement has imaging optics for imaging the spectral components in a focal plane, wherein a periodic structure is provided in or in the vicinity of the focal plane for wavelength-dependent influencing of the illumination light, with a structure composed of a plurality of parts of different periodicity.

232. (New) The arrangement according to claim 227, for sequential recording of the individual images with changed image phase by displacement of the structure (PE) at right angles to the optical axis.

233. (New) The arrangement according to claim 227, for sequential recording of the individual images with changed image phase by adjusting the position of a scanner.

234. (New) The arrangement according to claim 227, for sequential recording of the individual images with changed image phase by tilting a plane-parallel plate.

235. (New) The arrangement according to claim 227, for sequential recording of the individual images with changed modulation frequency with means for changing the imaging scale in a wavelength-dependent manner.

236. (New) The arrangement according to claim 227, for sequential recording of the individual images with changed modulation frequency by swiveling in different gratings with different periodicity.

237. (New) The arrangement according to claim 227, for sequential recording of the individual images with changed modulation frequency by displacement of a periodic structure, whose period changes at least in one spatial direction (Y) vertical to the direction of periodicity (X), vertical to the periodicity.

238. (New) The arrangement according to claim 227, for generating a plurality of light distributions on the specimen and parallel recording of the individual images.

239. (New) The arrangement according to claim 227, for generating a plurality of light distributions on the specimen and parallel recording of the individual images with one wavelength, especially by splitting the illumination into a plurality of partial beams with a beam splitter arrangement comprising at least one full mirror and a partially transmitting mirror and/or splitting the illumination into a plurality of partial beams with at least one mirror and a reflecting periodic structure acting as beam splitter.

240. (New) The arrangement according to claim 227, for generating a plurality of light distributions on the specimen and parallel recording of the individual images with a plurality of wavelengths, especially by splitting the illumination into a plurality of partial beams with a dispersive element and/or splitting the illumination into a plurality of partial beams by a beam splitter arrangement comprising at least one full mirror and a partially transmitting mirror, splitting the illumination into a plurality of partial beams with at least one mirror and a reflecting periodic structure acting as beam splitter.

241. (New) The arrangement according to claim 227, for parallel recording of the individual images with different phase positions of the illumination.

242. (New) The arrangement according to claim 227, for parallel recording of the individual images with different phase positions of the illumination, with a plurality of

wavelengths, especially with an arrangement with a dispersive element, wherein a periodic structure is rotatable about the optical axis, and the dispersive element is preferably arranged in the intermediate image, and/or an arrangement with a dispersive element, wherein the periodic structure comprises a plurality of parts of different periodicity and/or arrangement with a dispersive element, wherein the periodic structure is reflecting and acts as a beam splitter.

243. (New) The arrangement according to claim 227, for parallel recording of the individual images with different phase positions with one wavelength, especially by splitting the illumination into a plurality of partial beams with a beam splitter arrangement comprising at least one full mirror and a partially transmitting mirror and/or splitting the illumination into a plurality of partial beams with at least one mirror and a reflecting periodic structure, wherein the structure is rotatable about the optical axis, and/or by splitting the illumination into a plurality of partial beams with a beam splitter AO comprising at least one full mirror and a partially transmitting mirror or splitting the illumination into a plurality of partial beams with at least one mirror and a reflecting periodic structure, wherein the structure comprises a plurality of parts.

244. (New) The arrangement according to claim 227, for parallel recording with different modulation frequency.

245. (New) The arrangement according to claim 227, for parallel recording with different modulation frequency with a plurality of wavelengths, especially with an arrangement with a dispersive element and a periodic structure whose period changes at least in one spatial direction (Y) essentially vertical to the direction of periodicity (X), and/or an arrangement with a dispersive element and a periodic structure, wherein the periodic structure comprises parts of different periodicity, wherein the dispersive element is preferably arranged in the intermediate image.

246. (New) The arrangement according to claim 227, for parallel recording with different modulation frequency with one wavelength, especially by splitting the illumination into a plurality of partial beams with a beam splitter AO comprising at least one full mirror and a partially transmitting mirror and/or splitting the illumination into a plurality

of partial beams with at least one mirror and a reflecting periodic structure acting as beam splitter and/or with a period structure whose period changes at least in one spatial direction (Y) essentially vertical to the direction of periodicity (X), and/or by splitting the illumination into a plurality of partial beams with a beam splitter AO comprising at least one full mirror and a partially transmitting mirror or splitting the illumination into a plurality of partial beams with at least one mirror and a reflecting periodic structure acting as beam splitter, wherein the periodic structure comprises parts of different periodicity.

247. (New) The arrangement according to claim 227, wherein at least one dispersive element is provided in front of the detector arrangement.

248. (New) The arrangement according to claim 227, in a microscope, preferably a laser scanning microscope.

249. (New) The arrangement for the excitation of optical specimen interaction in a plurality of specimen points according to claim 227, wherein a light beam is divided into at least two partial light beams, the partial light beams are superimposed interferometrically and shaped to form a line in which examined specimens are imaged, the occurring scan line which is modulated with a periodic structure is scanned over the specimen, and images with different phase positions of the structure are recorded on the line and confocal section images are calculated.

250. (New) The arrangement according to claim 227, wherein the partial beams are generated by a pupil division.

251. (New) The arrangement according to claim 227, wherein the partial beams are generated by a Fresnel biprism.

252. (New) The arrangement according to claim 227, wherein an adjustment of the image phase is carried out by means of rotating the biprism.

253. (New) The arrangement according to claim 227, wherein different wavelengths of the partial light beams are adjusted for frequency coding.

REMARKS

Claims 1-134 have been cancelled and new claims 135-268 have been added.
The amendments to the claims have been made only to improve the form of the claims for examination purposes.

The specification has been amended to conform it to U.S. format and an Abstract of the Disclosure has been added.

As required, a substitute set of drawings is enclosed.

An early and favorable action on the merits is respectfully requested.

Respectfully submitted,

By: 

Gerald H. Kiel
Reg. No. 25,116

April 25, 2002
REED SMITH LLP
375 Park Avenue
New York, NY 10152-1799
GHK:jl

Enc.: Substitute Specification
Abstract of the Disclosure
Substitute Drawings